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Some Observations On Winter Injury In Utah Peach Orchards

December, 1924

T. H. ABELL

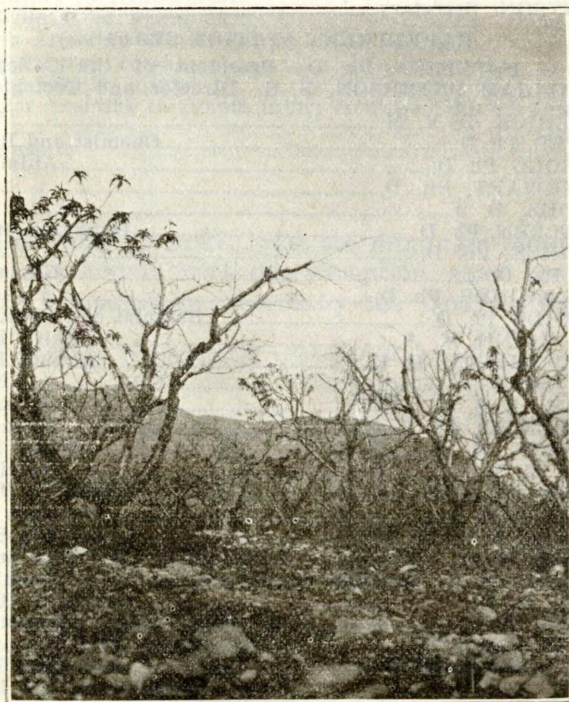


FIG. 11.—Peach trees severely pruned in January, 1925.
(Photographed May 17, 1925)

UTAH AGRICULTURAL EXPERIMENT STATION

LOGAN, UTAH

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SOME OBSERVATIONS ON WINTER INJURY IN UTAH PEACH ORCHARDS, DECEMBER, 1924*

T. H. ABELL

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From December 18 to 27, 1924, the minimum temperatures in Utah were the lowest, with one exception, since the beginning of statewide temperature records by the Weather Bureau¹.

TABLE 1.—*Minimum Temperatures (Fahrenheit) for December, 1923, 1924*

Station	1923	1924
Logan.....	+ 4	-25
Brigham.....	- 3	-24
Ogden.....	+ 4	-17
Riverdale.....	+ 5	-16
Farmington.....	+ 4	-16
Salt Lake City.....	+12	- 8
University of Utah.....	+ 8	-14
Lower Mill Creek.....	+ 8	- 5
Provo Bench.....	+ 2	-28
East Provo Bench.....	+ 2	-28
Provo.....	0	-35

The accompanying chart (Fig. 1) and Table 1, showing minimum temperatures at the weather stations in the fruit-growing sections, indicate just how much the temperatures departed from those of the normal winter of 1923.

During the winter following the freeze, fruit growers in Utah were deeply concerned over the effects of the cold on their orchards, since it was observed that not only were fruit buds killed, but the tissues of the trunks, limbs, and twigs were turn-

*Approved for publication by Director, 1 June 1927.

¹U. S. D. A. Climatological Data, Utah Section, Vol. 26 (1924), No. 13, p. 57.

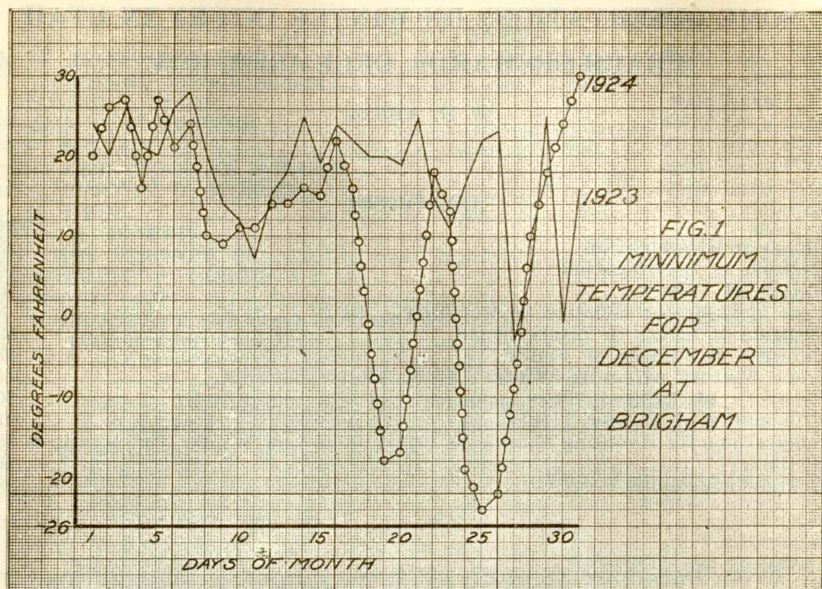


FIG. 1.—These curves are typical of the temperature trends at other stations where observations were made.

ing brown. The question at once arose as to whether or not this browning indicated the approaching death of the trees. It was, therefore, considered important to determine, if possible, the nature and extent of the damage, to discover any factors which might have favored or lessened the injury, and finally to offer suggestions to the orchardist for avoiding in the future the maximum amount of injury to his trees.

METHODS OF INVESTIGATION

An examination of the temperature chart will show that the low temperatures occurred between December 18 and 27. This chart is typical for those of all the stations.

During February, 1925, frequent visits were made to the peach and cherry orchards on the Experimental Farm (Logan) to examine the wood and buds and watch the progress of the browning of the tissues.

Beginning early in March a systematic series of visits was made to numerous orchards thruout the fruit-growing sections from Logan in Cache County at the north to Mapleton in Utah County at the south. In all, 92 orchards were visited more or

less regularly, and many other orchards were paid occasional visits. These orchards were distributed by counties as follows:

Cache	10
Boxelder	18
Weber	15
Davis	17
Salt Lake	6
Utah	26
Total.....	92

The regular visits were made approximately as follows:

March 6, 1925	September 10, 1925
April 10, 1925	October 16, 1926
May 15, 1925	May 20, 1927
June 8, 1925	

Observations were made and records kept of soil conditions, cultural methods, irrigation and water-supply, pruning, location, and varieties. An effort was made to learn the treatment given each orchard the previous summer. In most cases specimens of the limbs were taken for microscopic examination. Beginning in May an increment borer was used to sample the trees. Photographs were taken in many orchards.

Most of the observations were made on Elberta and Early Elberta peach trees since they were apparently most injured. Unless otherwise stated, the discussion which follows concerns these varieties.

Since an extended account of the data from each orchard would be inordinately long and the facts apparently unrelated, it is deemed best to begin at once with a discussion of the data from all orchards.

THE NATURE OF THE INJURY

The injury from low temperature in Utah fruit orchards in December, 1924, was found to be primarily a cambial injury, in some cases extending inward into the wood and out into the bark.

Figures 2, 3, 4, and 5 show the typical appearance of Elberta trees and tissues in March following the freeze. The very dark areas appeared, under the microscope, as layers of discolored, collapsed cells (see Fig. 3).

As might be expected, there was a wide range of discoloration in the trees examined. These different degrees of discoloration as observed in March and April, 1925, may be classified into seven fairly distinct groups, as follows:

(1) Trees with only a slight darkening or water-soaked appearance of the cambium of trunk, usually on the south or southwest side, limbs, and twigs.

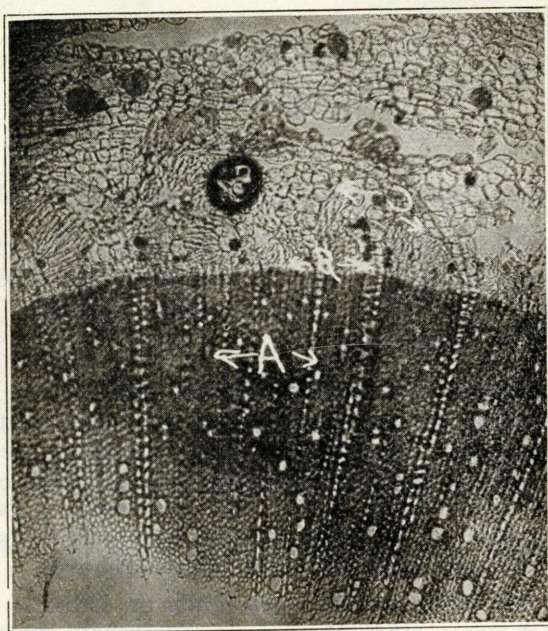


FIG. 2.—Unfrozen peach wood and bark. A: wood tissue or xylem; B: cambium or growing region of stem; C: phloem or food-conducting tissue, inner portion of bark.

(2) Trees with brown cambium principally in the twigs which by April were shriveled and dry.

(3) Trees in which the wood and bark of trunk and lower branches were discolored, but the cambium of which was apparently uninjured.

(4) Trees in which the cambium was brown in March on the south side of the tree from the snowline to the tips of the twigs. Under the microscope this brown discoloration was “patchy”, it being noticeable that the medullary rays out into the bark were of normal color.

(5) Trees with very dark brown complete discoloration of the cambium above the snowline in trunk, branches, and twigs, the injury confined to the south side of the trunks and branches, the north side being normal. Many twigs were more or less shriveled and dry by April.

(6) Trees with very dark brown or black cambium above the

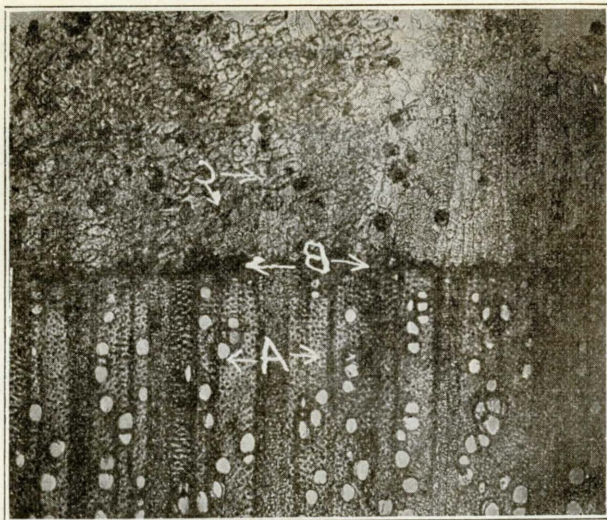


FIG. 3.—Frozen peach wood and bark: A: wood tissue or xylem; B: cambium or growing portion of stem. Note the dark collapsed condition of these cells; C: phloem or food-conducting tissue.

snowline in trunk, branches, and twigs, the discoloration extending all the way around the tree. One-year-old twigs were badly shriveled and dry by April. On young trees, live buds below the snowline where cambium was uninjured pushed out a vigorous growth in April and May before the upper parts showed signs of life.

(7) Trees with dark cambium, wood, and bark, some trees being brown from the surface of the bark to the center of the heartwood. Limbs or trees of this type were very hard and tough when cut into with a knife; they did not have the soft "cheesy" texture of normal live wood. Twigs in these trees were dry and brittle by March.

This browning of the tissues increased or deepened in color in the badly injured trees as the spring advanced, reaching maximum darkness by June. In the less injured tissues of the first two or three classes described above, there was apparently some fading of the discoloration as the trees recovered and became active.

Especial note should be made of the fact that a heavy snowfall a few days before the first drop in temperature and again in the day or two between that and the second low temperature piled the snow around the trunks of the trees, protecting an area of the trunk reaching six to twelve inches above ground.

Another important item is the fact that the most noticeable injury was in the trunk and lower branches. This will be discussed later under Factors Affecting Injury on page 14.

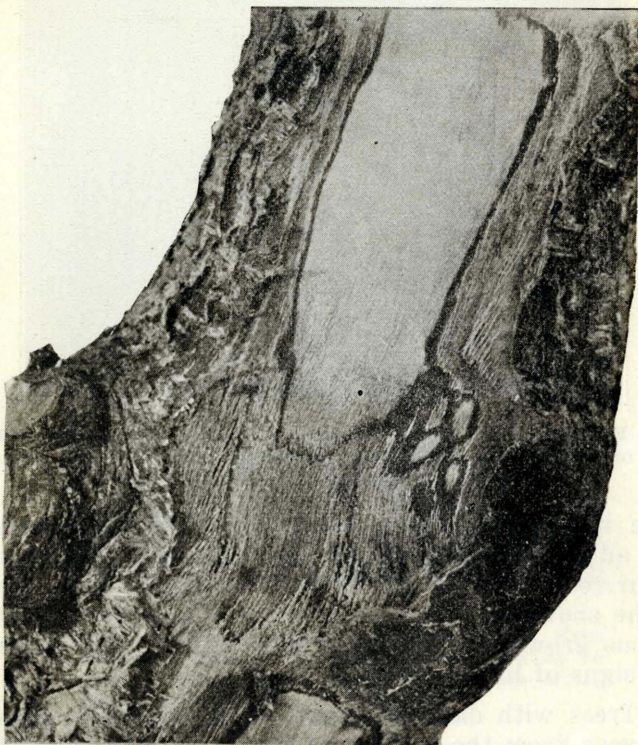


FIG. 4.—Typical cambial injury in peach limb.

TYPE OF INJURY IN RELATION TO MORTALITY

Because fruit growers are interested in determining at the earliest possible moment just how badly their trees are damaged, this point is of great importance. It would be highly desirable to be able to foretell by an examination of the tree what its chances are for further life and crops after a severe freeze.

With reference to the foregoing seven classes of injury the following statements regarding mortality give a general idea of the seriousness of each type of injury:

Class 1.—Trees recovered and even bore a small crop of peaches; many fruit buds were killed.

Class 2.—Trees recovered by sending out new shoots below

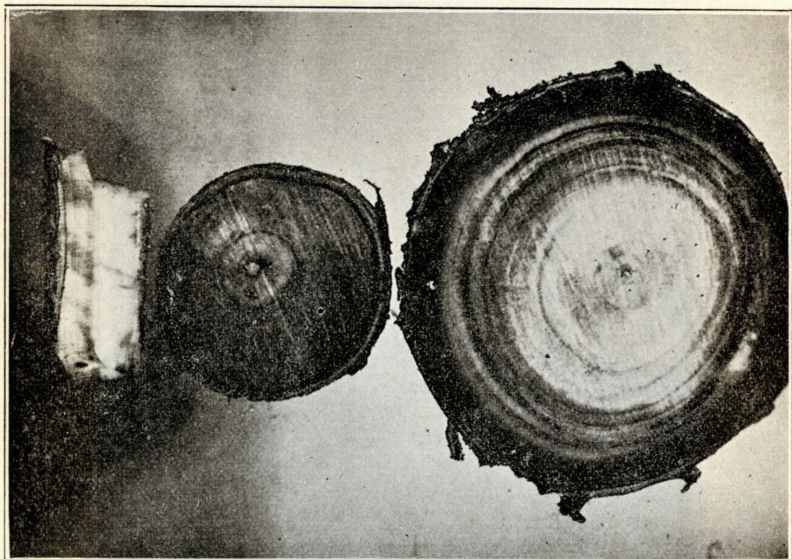


FIG. 5.—Sections of peach twigs. Left: live tissues uninjured; middle and right: bark, cambium, and wood injured and discolored.

the dead twigs at the tips. This condition was found more in young than old trees. An occasional fruit matured.

Class 3.—Trees recovered and some bore a small crop of peaches.

Class 4.—Trees recovered with no spreading of the discoloration, which in some cases even appeared to fade. Fruit buds were killed.

Class 5.—Practically all young trees recovered with the occasional death of branches and twigs, but the discoloration spread into the heartwood so that branches often had brown or blackened heartwood surrounded with new growth. There was no fruit. Trees in this class often developed crotch cankers due to the death of tissues in the crotch between two branches.

Most old trees with this type of injury recovered, but there were a few orchards in which many branches and several trees were killed or died during the following summer. This mortality was most pronounced in trees in noticeably poor condition. There were also some crotch cankers; the fruit buds were killed.

Class 6.—Most young trees of this class recovered, but blackheart and large and numerous frost cankers developed. In May, 1927, many of these frost cankers, either in the crotches or on the southwest side of the trunks, were so large as to

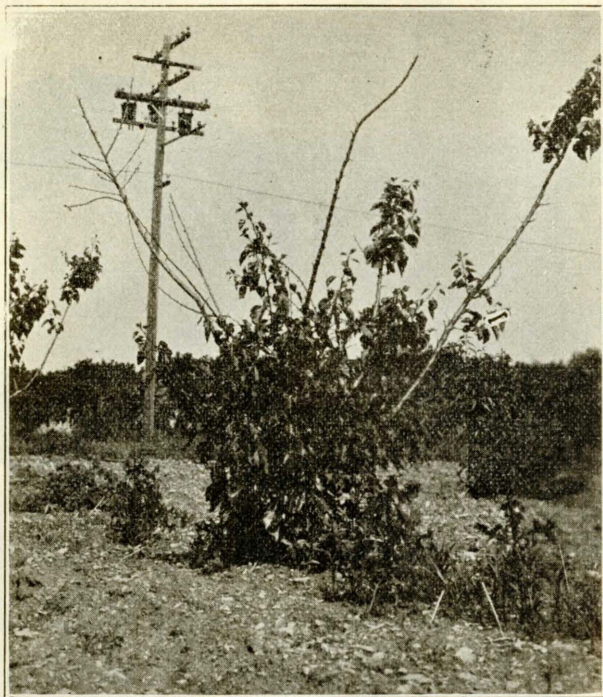


FIG. 6.—Injured apricot tree, the top of which is dead.
Note the new growth from the uninjured trunk.

seemingly seriously menace the future strength and vigor of the trees. A further characteristic of those trees which did recover was the very slow opening of buds in the parts above the snow-line, whereas the buds below the snowline pushed out early and vigorously. In several cases the injured top died, and these shoots from the base made all the new growth for the season (Fig. 6). In many trees but one or two branches survived, which resulted in trees with poorly shaped tops (Fig. 7). Especially when some other detrimental condition existed in the orchard, some trees of Class 6 died during the spring or summer following the freeze. Even in orchards where the cultural and environmental conditions were apparently ideal, several trees were dying in May, 1927.

Old trees with injury of Class 6 suffered much more than young trees in the same or adjacent orchards. Many of these old trees died either the following spring or during the two following summers. In many other trees several branches died leaving the trees unbalanced; hence, a large percentage of the

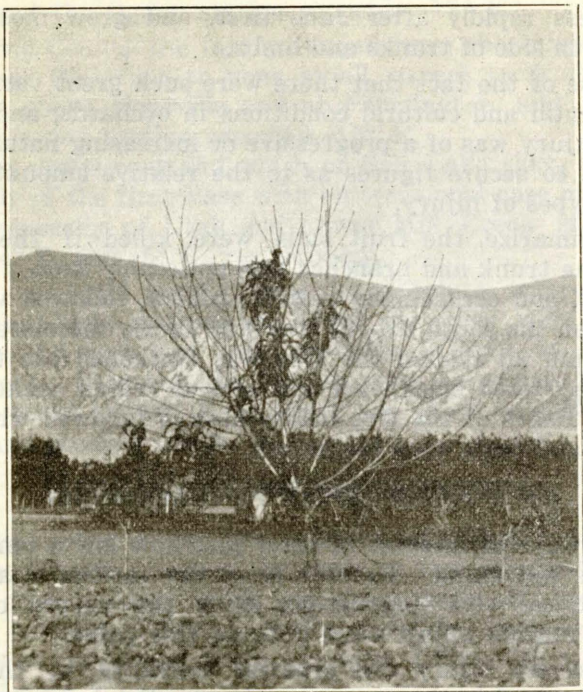


FIG. 7.—Injured peach tree.

bearing area of the orchard was destroyed. Blackheart and crotch cankers developed in trees which survived. In such orchards branches have continued to weaken and die (Fig. 11). The amount of mortality was increasing in May, 1927. Most live trees produced the new growth only at the extreme tips of the branches, the twigs in the inner and lower parts failing to recover.

Class 7.—Many old trees subjected to relatively unfavorable cultural or environmental conditions received injury of Class 7. Trees and branches with such injury seldom recovered, or merely sent out a few sickly yellow leaves which were not sufficient to revive the growth in the rest of the tree. Ordinarily, not all the trees in an orchard were affected, but there were usually enough to make the orchard unprofitable (Fig. 10).

In trees having injury of the last three classes, the microscopic examination of injured tissue showed all cambial cells of the discolored areas apparently to be dead, yet in trees and branches which recovered a layer of new growth was made outside the injured area. This new growth appeared early in April

as a layer of white spongy cells over the dead tissue, increased in thickness rapidly after June first, and grew most rapidly on the north side of trunks and limbs.

Because of the fact that there were such great variations in environmental and cultural conditions in orchards, and further, that the injury was of a progressive or increasing nature, it was impossible to secure figures as to the relative amounts of the different types of injury.

To summarize, the fruit buds were killed if the cambial layer of the trunk and branches was noticeably brown. Usually blackheart, and occasionally crotch cankers, followed when the cambium on the south side of tree was darkly discolored. When the cambium all around the tree was blackened the tree died, or, if it recovered blackheart and serious crotch cankers often resulted. Death of the tree nearly always followed when wood, cambium, and bark were blackened.

RELATION OF INJURY TO TEMPERATURE

It is always of interest to know just how low a temperature fruit trees will stand. Records from the various weather stations combined with observations as to the nature of injury near each station afford some data on this point.

Most severe injury and greatest mortality, in the region studied, occurred in the areas near Logan, Brigham, Roy, Provo, and Springville.

Near Logan, injury of the sixth and seventh classes in which peach trees were killed outright followed a minimum temperature of -25° F.

Injury of the last three classes occurred between Brigham and Perry, there being less of the seventh class than near Logan. At Brigham the temperature was -24° F.

On the sandy ridge near Roy there was some injury of the sixth and seventh classes, but more of the first, fourth, and fifth classes. The nearest weather stations at Ogden and Riverdale reported -17° F. and -16° F., respectively. An unofficial report at Roy gave -22° F. This is approximately 200 feet above the Ogden station.

In orchards on Provo Bench, there was much injury of the fifth and sixth classes but relatively less mortality than elsewhere. Similar injury was observed on the Springville-Mapleton bench. The Provo and Provo Bench stations reported -35° F. and -28° F., respectively.

Less severe injury and very little mortality occurred near the other stations.

Near Willard and in North Ogden the injury was largely of

first, fourth, and fifth classes. There is no weather station at Willard, and the Ogden station reported -17° F.

In Davis County the injury ranged from the third and fifth classes near Clearfield to none at all, except to fruit buds, on the bench above Kaysville and at Farmington and Bountiful. The Farmington station reported -16° F.

On the slopes east and south of Salt Lake City, the injury was mostly of the first class with an occasional case of the sixth class. University of Utah and Lower Mill Creek stations reported -14° F. and -5° F., respectively.

Thus, one could hardly name an absolute temperature at which either buds or trees are killed, for trees were killed at -25° F. near Logan and only partially injured at -28° F. on Provo Bench. However, the data do seem to indicate that peach trees subjected to -20° F. or lower are likely to suffer serious damage and possibly death.

RELATIVE HARDINESS OF FRUITS

The discussion so far has referred specifically to Elberta and Early Elberta peaches; however, a few observations were made on other fruits. While no exact ratio of hardiness is apparent between different fruits, possibly because of wide variations in conditions, there are some differences in hardiness worthy of note.

Peaches.—The degree and type of injury were about the same in Elberta, Early Elberta, Late Crawford, Hale's Early, and J. H. Hale. Carman, Rochester, Alexander, and Triumph were more hardy than Elberta. Rochester and Carman produced a few fruits where the Elberta produced none. Elberta developed many serious crotch cankers, while under identical conditions none developed on the J. H. Hale variety.

Apricots.—In most cases apricots were injured less than peaches, but in exceptional cases they were injured as much or more. In many cases badly injured Chinese apricots bore fruit where peaches did not. Old trees of the Royal apricot were injured less than old trees of the Chinese and Moorepark varieties. Jones apricots were killed where young Elberta trees of the same age recovered.

Apples.—Apples were more hardy than the stone fruits. In Cache Valley, however, where peaches were killed outright, Jonathan trees suffered with injured wood, many trees having almost the whole wood cylinder blackened. Mortality of branches and trees was not apparent until 1926. "Wrinkled" apples, another aftermath, will be further described.

Cherries.—Cherries suffered generally much less than peaches. Frequently, even the discoloration of cambium, wood, and bark occurred, a high percentage of fruit buds was uninjured. Quite generally sweet cherries bore crops where peaches did not. Lambert trees appeared to be more hardy in both wood and fruit buds than Bing, Napoleon, and Winsor. Peculiarly, Montmorency sour cherries developed frost cankers where none developed in Napoleon. Most cherry trees recovered.

Grapes.—Adjacent to Elberta peaches which received Class 6 injury and bore no fruit, Concord grapes were uninjured and bore a crop.

Pears.—Where young peach trees were killed, young pears were uninjured. In one place, the wood at the base of fruit buds was brown, but this did not affect the vitality of the bud.

Plums and Prunes.—With a few exceptions, plums and prunes were injured to a less extent than peaches. Japanese plums were more hardy than Peach plum, Italian, Tragedy, and Golden Drop. No death of trees was observed.

Nuts.—English walnuts appeared to be of variable hardiness. Most trees were injured and delayed in starting growth in the spring, but surprisingly few branches and trees were killed. Severe injury to walnut trees usually occurred where injury to peaches was of Classes 5, 6, and 7.

SOME FACTORS AFFECTING WINTER INJURY

The amount and type of injury and percentage of mortality resulting varied so within short distances that, to the unobservant, there would appear to be a maximum of "freakishness" in the damage done by the low temperature. As before stated, one object of the investigation was to discover factors which favor or lessen the injury and hence explain the variable effects.

Altitude.—The first factor noticed was that orchards at high elevations were injured less than those on lower levels. There were numerous instances where orchards on the Provo Bench Level (4770 feet) were severely injured, while nearby orchards on higher levels were less injured and in some cases even bore a crop of fruit.

An interesting example of this is a peach orchard on East Provo Bench which bore no crop in 1925, while another block of 300 trees located a few rods away on the next bench, 75 or 80 feet higher in elevation, bore 400 bushels of peaches that year. In another instance at Brigham City, there were a few peaches in 1925 in an orchard on a high bench one quarter of a mile

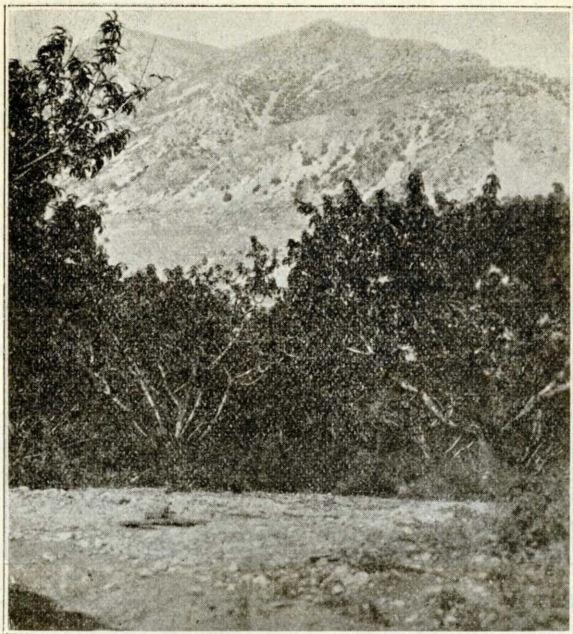


FIG. 8.—Peach trees manured in 1924.
(Photographed May 17, 1925)
Compare with Figure 9.

from and 100 feet above an orchard in which all fruit buds and many trees were killed.

These observations are interesting in view of the findings of Batchelor and West² who have brought out the fact that higher temperatures prevail on the bench lands in the valleys during clear, frosty nights in spring. This same difference in temperature undoubtedly existed during the December freeze of 1924. Unofficial thermometer readings show differences of approximately 10 degrees at differences of about 75 to 100 feet in elevation on those cold nights.

In many northern fruit-growing sections which are just within the region adapted for growing stone fruits, it is common experience to discover "warm thermal belts", or comparatively narrow strips of land at certain elevations, or adjacent to large lakes, where winter temperatures are more moderate, fall freezes less frequent, and late spring frosts more rare than in the adjoining territory. These "thermal belts" are exceedingly valuable for the production of tender fruits. These com-

²Batchelor, L. D. and West, F. L.—Utah Agr. Exp. Sta. Bull. 141 (1915)

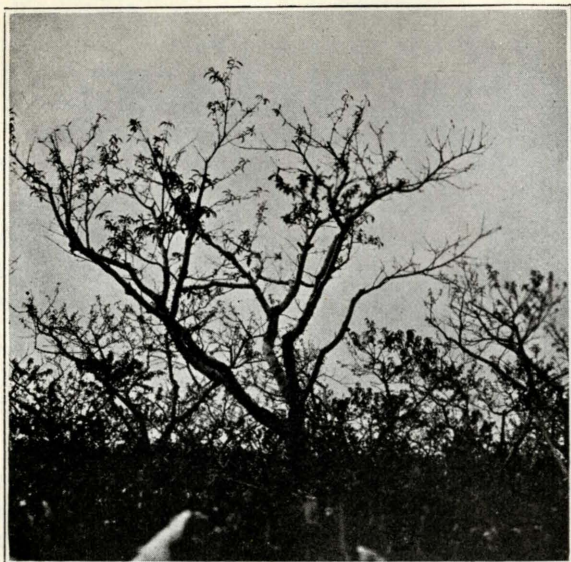


FIG. 9.—Peach trees not manured in 1924 (Photographed May 17, 1925) Compare with Figure 8.

paratively warm “thermal belts” are rather conspicuous all along the western slopes of the Wasatch Range from Logan to Payson, and could probably also be found in other districts and valleys.

**ORCHARDS PLANTED ON HIGH LANDS
ARE LESS LIABLE TO INJURY FROM BOTH
SPRING FROSTS AND LOW WINTER TEM-
PERATURES.**

Soil Type and Fertility.—One often hears the statement that a piece of land is worthless except for fruit trees. The thot appears to be that fruit trees need little fertility, and as a result the soil in the orchard is allowed to become impoverished; often no attempt is made to build up these naturally deficient soils.

Some orchards under these conditions were noticeably less resistant to the low temperature than nearby orchards on soil of good fertility.

In Brigham the owner of an Elberta peach orchard, on soil apparently naturally deficient in nitrogen and organic matter,

realized the importance of fertility and supplied stable manure to part of his orchard during the year previous to the freeze. More than 80 per cent of these trees recovered. In the block of trees which received no manure, approximately 50 per cent of the trees were killed and the remainder were much weakened (Figs. 8 and 9).

In another part of the orchard where the trees were younger, part of the trees received enough chicken manure to make them grow more vigorously and ripen the peaches later, in 1924, than trees not manured. In 1925, after the freeze, the manured trees were the more thrifty and there were fewer dead branches than in unmanured trees.



FIG. 10.—Peach trees which received no irrigation water for several years previous to December, 1924. (Photographed May 17, 1925)

ORCHARD SOIL FERTILITY IS NOT PERMANENT. FERTILIZING THE SOIL NOT ONLY IMPROVES THE CROPS, BUT INCREASES THE WINTER HARDINESS OF OLD TREES ON LIGHT SOILS.

Water-supply.—Owing to a very light snowfall in the winter of 1923-24, the supply of irrigation water in 1924 was abnormally low. This had a most pronounced influence on the susceptibility of trees to winter injury. Lack of adequate irrigation in an orchard was apparently the single most important, predisposing factor for death of trees. In a young peach orchard which received no irrigation in 1924, most of the trees died. Another peach orchard of older trees which received no irrigation for several years previous to the freeze is shown in Figure 10; this orchard has since been pulled. An irrigated orchard across the road recovered.

ALLOWING THE ORCHARD TO SUFFER FOR WATER IS AN INVITATION FOR WINTER INJURY. IN CASES OF WATER SHORTAGE, CLEAN CULTIVATION SHOULD BE PRACTICED.

An orchard of peach and apricot trees on sandy soil received insufficient irrigation during the summer of 1924. Trees at the lower ends of the rows received no irrigation after July 25. The upper part of the orchard was irrigated twice after that date. The trees which were inadequately irrigated did not recover, whereas those which received the later irrigations recovered fairly well; only an occasional tree and branch wilted the following summer.

TABLE 2.—*Precipitation in 1924*

Station	August		September		October		November	
	Precipitation	Departure from Normal	Precipitation	Departure from Normal	Precipitation	Departure from Normal	Precipitation	Departure from Normal
Logan.....	.04	-.61	.70	-.54	2.06	+.39	1.22	.00
Brigham.....	.38	-.19	.34	-.82	1.84	-.06	1.00	-.49
Ogden.....	.83	+.19	.30	-.60	2.96	+.51	1.33	+.14
Farmington...	.53	-.22	.81	-.47	1.76	-.16	1.66	+.13
Salt Lake.....	.30	-.48	.25	-.60	1.87	+.47	1.54	+.12
Provo.....	.36	-.32	.26	-.83	1.47	+.05	1.32	+.20

Immaturity and Winter Injury.—Immaturity of the trees is frequently named as one of the most common predisposing factors for winter injury. This would appear to be an explanation for the injury during the freeze of December, 1924, inasmuch as the greatest injury was to the trunk and lower limbs, while the outermost buds were less injured than those farther down in the tree. The supposition is that the trunk is the last part of the tree to mature. Such an explanation fits very nicely if one ignores the great injury in orchards receiving insufficient water during the previous summer; this fact can hardly be ignored, for many orchards suffered water shortage.

It has been suggested that the trees matured early in summer and then the tissues became active again under the influence of warm fall rains, hence were immature when the low temperature occurred. Table 2 shows the rainfall for the late summer and fall of 1924 and its departure from normal. Altho August and September were warm, the precipitation was below normal and hardly seems enough to account for late growth. On the other hand, precipitation in October and November was above normal, but the temperature was abnormally low so as to discourage plant activity.

Irrigation water-supply was very short in August and was exhausted in September in at least one large canal.

Whatever the explanation, it is quite evident that peach and apricot orchards in Utah cannot always be expected to survive low winter temperatures when there is insufficient water during the previous summer.

Peach Tree Borer.—Peach tree borers appeared to greatly increase the susceptibility of trees to injury, probably because they decreased the vigor of the trees by girdling. Orchards badly infested with borers were usually more seriously injured than those less infested; this was more pronounced in old than in young trees.

Pruning Practices.—Pruning the trees in the spring of 1925, following the freeze, often had an important influence on the death or recovery of the trees.

**BORERS WEAKEN PEACH TREES AND
MAKE THEM MORE SUSCEPTIBLE TO
WINTER INJURY. PARADICHLOROBENZINE
TREATMENT SUCCESSFULLY ELIMINATES
THIS PEST.**

In several orchards, where trees received injury of Class 6, heavy pruning in January and February proved disastrous. Evidently the pruning removed all the live buds at tips of branches, and the badly injured lower wood was unable to start adventitious growth to replace them, as ordinarily happens when normal trees are headed back (Fig. 11, cover cut). On the other hand, in several orchards dehorning apparently did no harm.

**BADLY INJURED OLD TREES SHOULD
NOT BE PRUNED UNTIL THE EXACT LOCA-
TION OF DEAD WOOD CAN BE DETERMINED.**

A few orchardists pruned their young trees under bearing age rather severely, while neighbors left theirs unpruned. The heavily pruned trees were, in May, 1927, somewhat smaller, there being practically no difference in recovery. A close examination of the trees reveals, however, that the unpruned trees often have a much larger percentage of frost cankers. In one case Elberta trees pruned severely in June showed practically no cankers, while an adjacent orchard of the same age unpruned showed practically one-third of the trees to have serious crotch cankers.

A few orchardists pruned young peach and sweet cherry trees back to the snowline. These trees, in May, 1927, were much smaller than those unpruned, but they have neither crotch cankers nor blackheart, as have many of the young unpruned trees.

The factors favoring injury cannot always be easily discovered, for one cause of death may be accompanied by, and confused with, another.

RECOVERY OF INJURED TREES

The recuperative powers of winter-injured fruit trees is remarkable. Trees in which all cambial cells and some adjacent wood and bark cells were brown, collapsed, and apparently dead, started a new layer of wood and bark cells outside the injured area, and rapidly covered up the blackened tissues. This occurred not only in trees injured on the south side, but also in those trees injured on all sides of trunk and branches.

One of the factors which apparently greatly favored the recovery of these trees was the heavy rainfall about June 1, 1925. A week after this rain, trees which before the rain had

only a sparse, sickly yellow foliage pushed out a more vigorous dark green growth of healthy appearance. Quite generally, trees which appeared to be on the verge of dying took on a more lively appearance after the rain, which was undoubtedly the turning point for large numbers of trees.

About May 16, 1925, small amounts of ammonium sulfate and sodium nitrate fertilizers were applied to injured peach and apricot trees in Brigham, Farmington, and near Provo. The peach trees were not noticeably affected one way or the other by the fertilizer. Apricot trees, however, responded remarkably with a vigorous new growth, while the unfertilized trees either died or lost many branches. Perhaps earlier use of the fertilizer for peaches would have had a favorable effect.

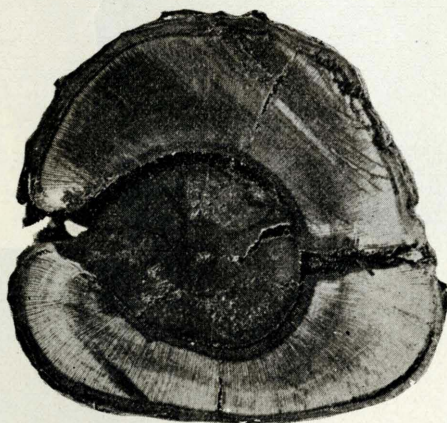


FIG. 12.—Peach limb affected with blackheart. (Photographed September, 1926)

AFTERMATHS OF WINTER INJURY

The detrimental effects of a low winter temperature are not all confined to death of branches and trees and loss of crop the following year in trees which recover. The final result may be delayed for several months or possibly years.

Blackheart.—Recovered peach trees which had injury of the fifth and sixth classes usually developed blackheart, browning or blackening of all the wood inside the cambial ring of 1924 (Fig. 12). If this dead tissue remains sealed up in the new growth it will likely do no damage. However, pruning, mechanical injury, or checking of wood may expose this dead area to the air, which will provide an opportunity for the entrance of wood rot fungi and the drying out of live wood from cracks. As



FIG. 13.—Crotch canker in peach limb, as seen from above.

a result, the interior of the branch decays and its mechanical strength is weakened.

The drying out and discoloration of new wood from within is evident in Figure 12. In the fall of 1926, the breaking of branches with normal loads of fruit was common in young trees with blackheart. This weakness and breaking of limbs will likely become more frequent as crops in young trees become larger.

Blackheart is also very pronounced in winter-injured Jonathan trees, as well as in all badly injured stone fruits.

Crotch Cankers.—Crotch cankers are frost-killed areas in the crotches of trees. They were rather prevalent in young peach and sweet cherry trees, and, to a lesser extent, in old peach trees. Some of the factors favoring their occurrence



FIG. 14.—Frost cankers on peach tree.
(Photographed June, 1925)

have already been discussed. Evidently the tissues in and adjacent to crotches were least mature or least hardy of any in the badly discolored trees. The canker is easily recognized by the shrinking of the killed area and the increase in thickness of the living bark around it (Fig. 13). The cankers varied in size from an area one inch in diameter to narrow strips extending two feet along the adjacent branches (Fig. 14). Small cankers healed over by the end of summer 1925, but large ones may require several years to be completely covered.

CROTCH CANKERS SHOULD BE ELIMINATED BY PRUNING THEM OFF AND SHAPING THE TREE WITH OTHER LESS INJURED LIMBS.

Even tho these cankers heal from the sides, the crotch will always remain weak, because the edges of the callous growth do not knit. Hence, the branches increase in size, weight and crop capacity, but the dead crotch is not increased in strength in proportion. It is probable that before long heavy crops of fruit will expose these weak spots in the trees. These cankers are unfortunately low down in the main framework of the trees, so that when breakage does occur it will be difficult to reshape the trees.

In addition to cankers in crotches there are many frost cankers on the southwest side of trunks.

Delayed Mortality.—During the two years following the freeze, limbs and trees have continued to lose vigor and die.

For example, in Cache Valley a Jonathan orchard exhibited no apparent injury until the summer of 1926, when, on branches thruout the orchard, leaves turned yellow and withered and fruit stopped growing. An investigation into the trunk and limbs showed the presence of blackheart.

In some sweet cherry and apricot trees the death of branches occurred during the first summer when the fruit was half-grown. The leaves and fruit withered and dropped and the limbs died.

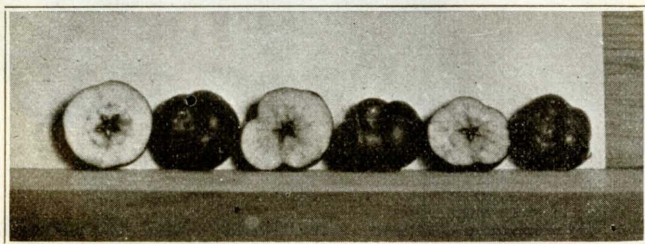


FIG. 15.—“Wrinkled” apples (Jonathan variety).
(Photographed October, 1925)

Wrinkled Apples.—In the fall of 1925, wrinkled apples usually accompanied blackheart in Jonathan apple trees. There was very little in other varieties. These apples were deeply creased or indented along lines running from stem to calyx, so that they had the appearance of deeply lobed tomatoes (Fig. 15).

It was noticeable that the indentations, or presumably inhibited areas, were adjacent to the fibrovascular bundles situated between the carpel lobes. They were seldom near carpels containing undeveloped seeds. This would seem to preclude the probability of any connection with seeds killed by frost. Insufficient water-supply to the fruit, due to the death of the conducting tissues of the trunk and branches, may offer an explanation for this phenomenon.

SUGGESTION FOR AVOIDING MAXIMUM INJURY
FROM LOW WINTER TEMPERATURES

As a result of the above observations, the following suggestions can be made to fruit growers regarding possible methods for avoiding, at least to some extent, injurious effects of low winter temperatures.

Wherever possible, tender varieties of fruits should be planted on the higher levels in the warm "thermal belts". With such fruits as sweet cherries, apricots, and peaches, this will also favor their escape from late spring frosts.

Commercial plantings should be made preferably on good soil. If the choice must be a soil deficient in nitrogen and organic matter, the supplying of those materials should not be neglected. The observations indicate definitely that trees of low vitality do not resist winter injury as well as the more vigorous trees.

Fruit trees should be planted only where a good water-supply is assured. Investigations of the Utah Experiment Station have shown that 30 acre-inches³ of water is necessary to produce a good crop of peaches. In existing orchards where water is scarce, it would seem most practical to keep the soil clean-cultivated, since intercrops such as alfalfa, sweet clover, or weeds will rob the trees of water. Where the cover crop is grown to supply organic matter it should be used only in years of sufficient moisture.

When there is a good crop, fruit can be improved by thinning even under the best conditions of soil fertility and moisture. In years of water shortage, however, thinning is especially desirable in order to insure sufficient water for the tree. Since it requires much moisture, the fruit might be sacrificed for the health of the tree.

If winter injury to trees is suspected the pruning of mature trees should be delayed until the degree of injury can be determined. Should the tissues be badly discolored, pruning should be delayed until growth has started to make sure that living buds are not removed.

Advice regarding pruning young trees not in bearing is rather hazardous, for much depends on the point of view of the grower. If the grower is interested only in the crops for the immediate future, the best practice would be to delay pruning until he can determine how much wood is actually dead. He can then prune the trees moderately, and in addition, remove any dead branches.

The detrimental effect of crotch cankers can be counteracted

³Batchelor, L. D. Utah Agr. Exp. Sta. Bull. 142 (1916)

by pruning in such a way as to eliminate the affected crotches from the tree, or by pruning off one branch of the two, thus eliminating the crotch weakness and allowing the dead area to heal over in such a manner that the branch is not seriously weakened. Frost cankers which have not healed over by the end of the first summer should be cleaned out, the dry area covered with white paint, and the tender living tissues covered with grafting wax.

If the grower is interested more in the future health and strength of badly injured trees under bearing age, there are two courses open: One is to head back to the uninjured parts near the snowline, thus eliminating all weakness from black-heart and crotch cankers, and start new tops from the resulting water sprouts. Some trees will be killed by this treatment so will need to be replaced; the rest should be supported with stakes to prevent sprouts from being blown off by the wind.

The other course of action is to pull the trees and replant. Many authorities favor this method over the former: (1) because it gives a better shaped tree and (2) because the trees will arrive at bearing age as soon as the pruned trees.

**FROST CANKERS SHOULD BE CLEANED
OUT AND PAINTED TO PREVENT FURTHER
SPREAD OF DECAY. GRAFTING WAX
SHOULD BE APPLIED TO EXPOSED LIVING
TISSUES.**

Whatever is done in the way of pruning, the dead twigs and branches should be removed as soon as possible after their condition is determined, because, even tho dry, they continue to evaporate moisture which they rob from the living parts.

SUMMARY

The low temperature in December, 1924, not only destroyed much of the stone-fruit crops in Utah but also did much damage to the trees.

The damage to trees was largely cambial discoloration. It was rather generally localized in the trunks and lower branches of the trees.

Careful note was made of the effect of various types and amounts of injury on the subsequent behavior of trees.

Death of branches and trees was greater where the cambial

discoloration was darkest. There was a higher percentage of death among old than among young trees.

Low vitality of trees, poor soil, insufficient water in 1924, frosty locations, and peach tree borers were apparently the most active predisposing factors which favored winter injury.

Severe pruning in old trees in January after the freeze frequently caused their death by removing most of the live buds at the tips of the branches.

Severe cutting back of young peach and sweet cherry trees was in some cases successful; in other cases it was followed by the death of the trees.

Differences in hardiness of various fruits were observed.

The most severe injury to trees was observed where the temperature went to -20° F. or lower. Peach trees bore small crops of fruit where the temperature the previous winter went to -16° F.

The recovery of injured trees was remarkable; practically all young trees of stone-fruit species made a good growth the summer following the low temperature.

Blackheart, frost cankers, and subsequent death of branches and trees were common aftermaths of the winter injury. "Wrinkled" apples in Jonathan trees were also thot to be a result of winter injury.

By May, 1927, blackheart and frost cankers of the crotch canker type were becoming rather serious in badly injured peach and sweet cherry trees. Weakening and death of trees in 1927 appeared to be associated with blackheart. Crotch cankers frequently resulted in limb breakage.

The locating of orchards on good soil, the use of high bench lands, increasing the soil fertility, maintaining an adequate water-supply in the summer, eliminating borers, thinning fruit in dry years, and a delay in the pruning of old trees are suggested as possible methods for avoiding the maximum injury to fruit trees by low winter temperatures.

The elimination, or the cleaning out and protection of frost cankers, is recommended.

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